
SUMMARY

This report is part of a project responding to a call by the U.S. Air Force to update cost estimating methodologies for new weapons systems—in particular, fighter aircraft. The Air Force was concerned that Cost Estimating Relationships (CERs) based on older aircraft did not adequately reflect the acquisition and manufacturing environment within which a new fighter, such as the Joint Strike Fighter (JSF) would be produced. This report is one of a series, all of which address some aspect of how to incorporate the new DoD acquisition and manufacturing environments into historical cost estimating relationships or methodologies (See Younossi, Graser, and Kennedy, 2001; Lorell and Graser, 2001).

Using the CER methodology for example, the cost of a future aircraft is estimated as a function of its physical or performance characteristics or other program variables, using a series of equations wherein the performance and program variables are inputs, and cost or labor hours are the outputs. To create these equations, actual costs (or labor hours) to produce previous aircraft are collected and used as the dependent variables in statistical regression analysis. Explanatory variables typically include such factors as cumulative production quantity, annual production rate, such aircraft characteristics as weight and speed, and others. The resulting equations are referred to as “cost estimating relationships,” or CERs. Obviously, the ability of these equations to forecast future systems costs hinges on how well past performance is a predictor of the future.

Manufacturers and many in DoD contend that because of revolutionary changes in the ways military aircraft are designed and built,

aircraft can be produced for lower costs than historical CERs would predict. They claim that new business practices, including the impact of lean manufacturing,¹ will enable significant savings over historical costs. These potential savings from lean manufacturing are of particular interest to the Air Force in the cost-conscious post-Cold War defense environment.

Because of the overlap of claimed savings due to new (post-1990) military aircraft design and manufacturing initiatives (especially for advanced airframe materials), acquisition reform, and lean implementation, RAND research was divided into four studies as follows:

- New fabrication and assembly processes related to advanced airframe materials are addressed in Younossi et al. (2001).
- Government changes in acquisition processes or changes in the relationship between the government and prime DoD contractors (known as “acquisition reform” implementation) are addressed in Lorell and Graser (2001).
- Lean implementation and other initiatives primarily oriented to processes within a prime airframe manufacturer or between these primes and their suppliers will be addressed in this report. To ensure completeness, this report also includes such initiatives as the introduction of technologies that “enable” or enhance lean manufacturing, but which purists might not categorize as lean.
- Propulsion impacts will be addressed in a report currently in work at RAND.

(See Appendix A for a listing of all military aircraft initiatives addressed in the first three of these reports.)

These savings claims by industry and some government officials were assessed using evidence provided during site visits by RAND researchers to all U.S. defense prime aircraft manufacturers, many of their major airframe subcontractors, and a small selection of lower-tier suppliers.

¹The lean manufacturing system is explained in detail in Chapter Two of this report.

This report addresses three questions regarding the adoption of lean manufacturing in the U.S. defense aircraft sector:

- To what extent have U.S. aircraft manufacturers implemented lean practices into their factories and what are the likely savings on military aircraft from this implementation?
- Is there sufficient documented and quantified evidence available from industry to support the notion that these savings should be incorporated into cost estimating methodologies?
- If so, what techniques should be used to modify cost estimating methodologies so estimates of future aircraft costs reflect the latest industry initiatives? Can a taxonomy be established for assigning these savings somehow into the Contractor Cost Data Reporting (CCDR) categories, which are the basic divisions under which actual cost data is collected about DoD aircraft under development or in production?

To briefly summarize the state of the lean implementation in the military aircraft industry in 1998:

- Nearly all of the manufacturers had embraced “lean,” as evidenced by the appointment of a Vice President or Director of Lean or of related affordability initiatives, whose main responsibility was implementation of cost savings efforts.
- Nearly all manufacturers had lean pilot projects in operation or planned for the near term.
- All of those manufacturers with pilot projects reported savings on the factory floor from these initial activities.
- None had implemented lean practices from beginning to end of the value stream or even “wall to wall” within the factory.
- Unions and the workforce in nonunionized plants had at least grudgingly accepted lean practices and principles because of the realization that any future job security depended on their companies’ abilities to produce affordable military aircraft.

Although anecdotal and pilot project evidence supported the contention that the implementation of lean manufacturing principles could reduce the cost of aircraft, it was impossible to fully assess the

claims regarding the magnitude of the effect of lean manufacturing on final aircraft costs because there was limited evidence of thorough, systematic implementation of the lean manufacturing system in any defense aircraft plant affecting its related product. Instead, lean implementation tended to be very localized within particular functions or on pilot projects. Savings from these pilot projects should not be generalized to forming predictions regarding the entire factory floor without further analysis because integrating individual “leaned-out” cells into a smooth continuous-flow production design is a separate and significant effort. The lean enterprise model also incorporates a great deal of change in areas outside the production facility, from engineering to supplier management to plant and corporate administration. Predicting the potential savings available from leaning out these areas cannot be done by generalizing the results from factory production cells.

The bottom-line finding of the report is that no macro adjustments to historical CERs are possible at this time because of the dearth of systematic data collection on the savings being achieved from strictly lean practices. This does not suggest that companies and government officials are not trying hard to reduce weapon system costs through the application of lean principles but that quantifying these savings into the bottom-line cost of systems in CERs must wait a few more years until actual data can be collected and analyzed. In the interim, we suggest that individual lean initiatives be analyzed and baseline cost estimates derived from historical CERs be discretely adjusted for these claimed savings on a case-by-case basis. This methodology is being used on the F-22 program through the Production Cost Reduction Plans (PCRP).

Readers should be able to take four points away from this document. First, they should get a broad overview of lean manufacturing and understand many of the specifics that go into a lean system. This material has been published (at least in part) in other reports, but it is presented as context and also to introduce lean manufacturing to readers who would like to learn more about it. Other presentations often focus on the automobile or other high-volume industries; this report discusses lean production in the specific context of the manufacture of military aircraft. In addition, we feel that the lean philosophy has more “staying power” than many of the other management philosophies of the recent and not-so-recent past, so cost estimators

must be knowledgeable of these principles and their potential impacts on cost as they develop estimates for military aircraft in the future.

Second, the report details the results of industry efforts described to RAND as of 1998 by military aircraft manufacturers. These include specific examples and claimed broad averages of cost savings.

Third, the report discusses the DoD Contractor Cost Data Reporting System and how lean manufacturing savings claims could influence costs in each category of the CCDR System.

Finally, the report discusses where companies need to push harder in lean implementation and what DoD can do to encourage this.